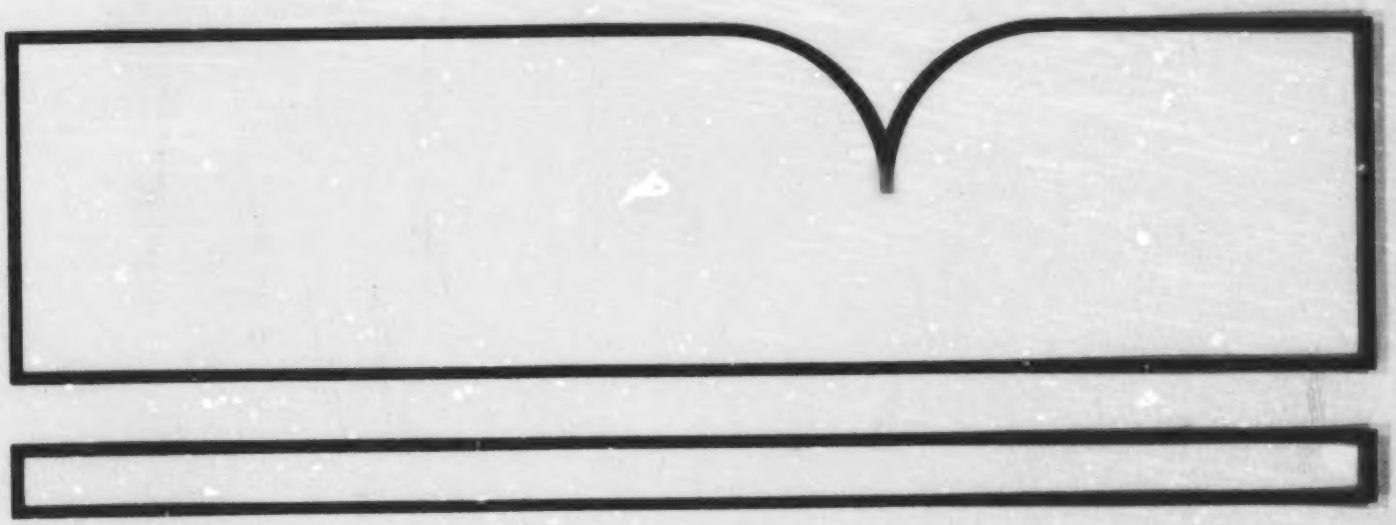
PB84-212463

Proposal for 1980 and Earlier Light-Duty Gas Vehicle Emission Factors for MOBILE3

(U.S.) Environmental Protection Agency
Ann Arbor, MI

May 84



U.S. Department of Commerce
National Technical Information Service
NTIS

PB84-212463

EPA-AA-TEB-EF-84-1

Proposal for 1980 and Earlier Light-Duty Gas Vehicle Emission Factors for MOBILE3

by

Thomas L. Darlington

May 1984

Test and Evaluation Branch
Emission Control Technology Division
Office of Mobile Sources
U.S. Environmental Protection Agency

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA-AA-TEB-EF-84-1		PB84 212463

4. TITLE AND SUBTITLE	5. REPORT DATE
Proposal for 1980 and Earlier Light-Duty Gas Vehicle Emission Factors for MOBILE3.	May 1984
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Thomas L. Darlington	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO.
U.S. Environmental Protection Agency Office of Mobile Sources Test and Evaluation Branch Ann Arbor, MI 48105	11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Same as box 9	Technical
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report discusses a proposal for new exhaust emission factor rates of hydrocarbons (HC) carbon monoxide (CO) and oxides of nitrogen (NOx). The new exhaust emission rates were developed for 1975-1980 light-duty gasoline vehicles at both high and low altitudes. The rates were not updated for the California region. The HC and CO rates were developed from a sample of vehicles that excluded those with evidence of air pump tampering, catalyst removal and misfueling. The NOx emission rates were developed from a sample that excluded the same vehicles plus those with evidence of EGR tampering. The HC and CO rates for 1980 are substantially lower than MOBILE2, while the HC, CO, and NOx rates for 1975-1979 are little changed from MOBILE2. Included in this report are the effect of these new rates.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Computer Programming Exhaust Emissions Mathematical Models Motor Vehicles Regulations	Emission factors Mobile Source Emissions Model MOBILE 3 Computer Program	

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release Unlimited	unclassified	17
	20. SECURITY CLASS *(This page)* unclassified	22. PRICE

EPA Form 2220-1 (9-73)

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1.0 SUMMARY

New HC, CO and NO_x emission rates were developed for 1975-1980 light-duty gasoline vehicles (LDGV's) at low and high altitudes. The rates were not updated for the California region. The HC and CO rates were developed from a sample of vehicles that excluded those with evidence of air pump tampering, catalyst removal and misfueling. The NO emission rates were developed from a sample that excluded the same vehicles plus those with evidence of EGR tampering. The new rates are shown in Table 1 below. The HC and CO rates for 1980 are substantially lower than MOBILE2, while the HC, CO, and NO_x rates for 1975-79 and the NO_x rates for 1980 are little changed from MOBILE2. The effect of these new rates on HC and CO emission factors for light-duty vehicles at low altitude is shown in Figures 1 and 2. Only the 1975-80 emission rates have been changed for these figures; all other rates are the same as in MOBILE2. It should also be noted that the 1975-80 emission rates used did not reflect misfueling, whereas the 1981 and later emission rates did. Including MOBILE2 misfueling effects in these new 1975-80 emission rates would have had the effect of narrowing the gap between the MOBILE2 and MOBILE3 lines.

Table 1

Emission Rates of 1975-80 LDGV's

		-----HC------		----CO------		---NOx----	
Region	MYR Group	ZML*	DR**	ZML	DR	ZML	DR
Low Alt.	1975-76	1.07	0.27	18.23	2.59	2.44	0.03
	1977-79	1.07	0.27	18.23	2.59	1.70	0.09
	1980	0.36	0.10	6.09	0.73	1.50	0.07
High Alt.	1975-76	2.02	0.27	43.07	2.59	1.70	0.03
	1977	0.95	0.27	16.97	2.59	1.42	0.09
	1978-79	2.10	0.27	39.78	2.59	1.00	0.09
	1980	0.78	0.10	22.80	0.73	0.82	0.07

* ZML = Zero mile level, gm/mi.
** DR = Deterioration rate, gm/mi/10K miles.

FIGURE 1
Effect of Using MOBILE3
1975-80 Emission Rates
on LDGV HC Emissions

NOTE: The MOBILE3 emission factor curve uses MOBILE2 emission rates for all years except 1975-80.

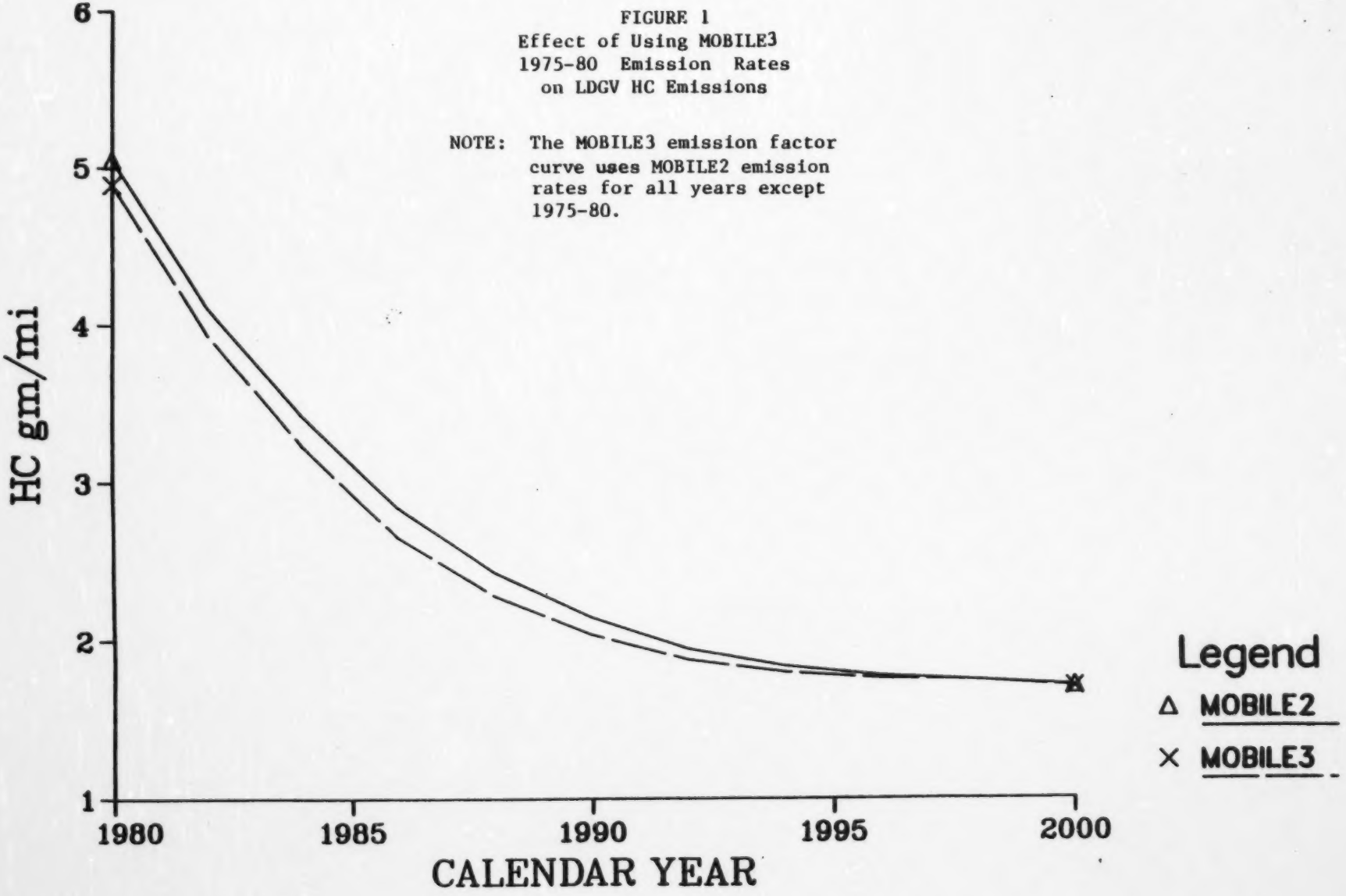
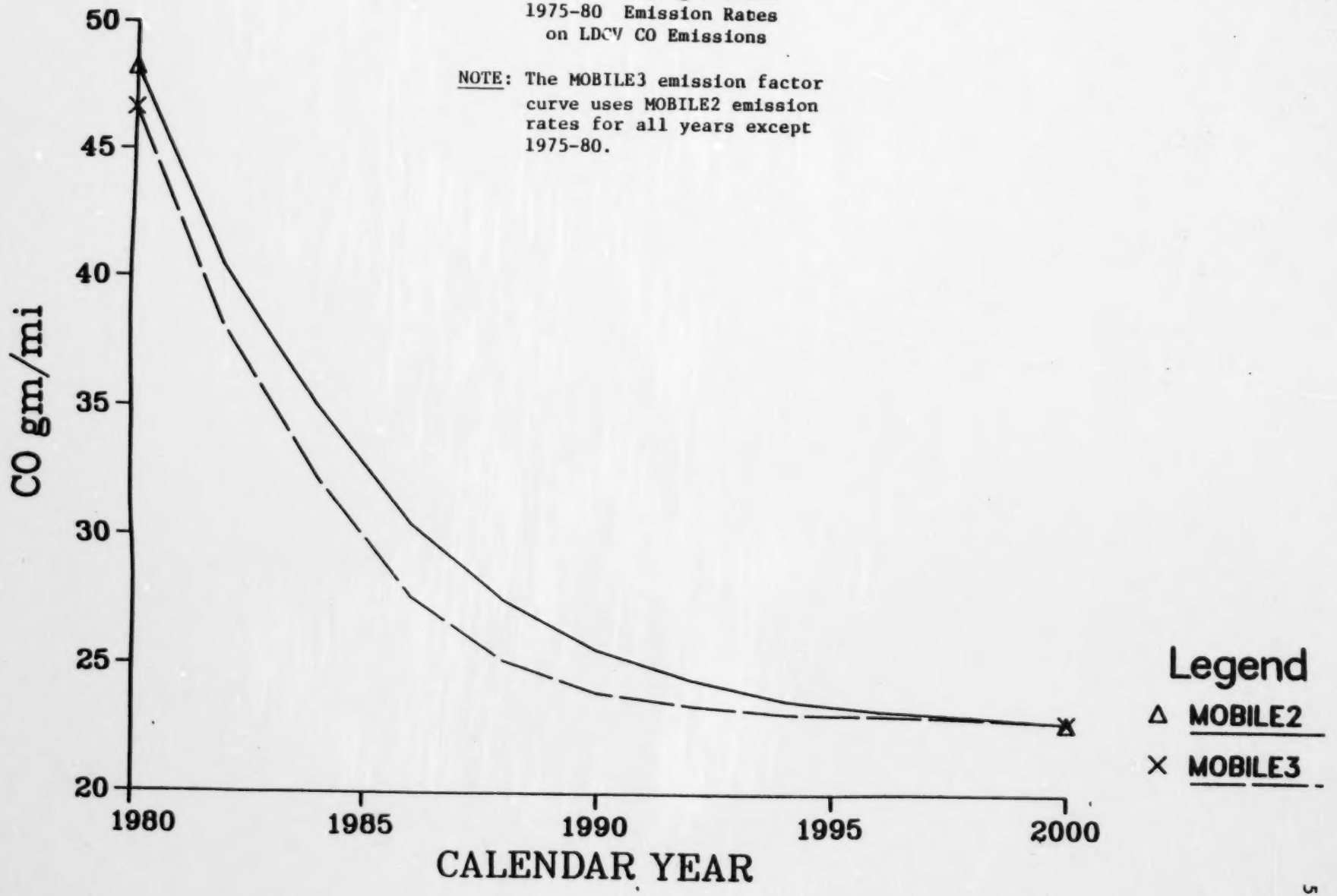


FIGURE 2
Effect of Using MOBILE3
1975-80 Emission Rates
on LDCV CO Emissions

NOTE: The MOBILE3 emission factor curve uses MOBILE2 emission rates for all years except 1975-80.



2.0 BACKGROUND

2.1 MOBILE2 Approach

The 1979 and earlier LDGV emission rates for MOBILE2 were developed from an analysis of covariance on all available low altitude, high altitude and California data in which mileage was the covariate and the regions were the strata. The analysis supported the assumption of equal deterioration rates and separate zero-mile levels for the regions.

For the 1980 model year, the deterioration rate was assumed to be the same as for 1975-79 LDGV's. The zero-mile level, however, was adjusted to reflect the fact that most 1980 LDGV's would be equipped with air pumps, and to reflect the fact that the HC and CO standards were lower for 1980.

The regressions obtained from the analysis of covariance were used as emission rates in MOBILE2 with one modification. Emission rates of predominately catalyst model year groups (i.e., 1975 and later) were compensated for misfueling effects, since it was felt that the Emission Factor (EF) test sample did not adequately reflect national average misfueling rates and effects. No adjustments were made for any other type of tampering such as catalyst removal or air pump disablement.

2.2 MOBILE3 Approach

The MOBILE3 analysis of pre-1981 LDGV emission rates will focus primarily on 1975-79 and 1980 emissions, since no new data have been collected on pre-1975 vehicles. The concept for MOBILE3 is to develop basic emission rates which reflect a no misfueling and tampering scenario, and then add the tampering and misfueling effects on separately. As a result, tampered vehicles must be identified and removed from the EF sample prior to performing analysis of covariance. This will be discussed further in Sections 3.1 through 3.3.

Analysis of covariance has been used to develop the 1975-79 emission rates for MOBILE3. Also, there was now enough data to use this same technique on 1980 model year vehicles. The California data were used to develop deterioration rates where technologies and emission standards were similar to the non-California low-altitude case. However, a specific analysis of California emission rates was not performed.

2.3 Other Items Pertaining to LDGV Emission Rates

Other items pertaining to the estimation of LDGV emission rates are also being updated as a part of MOBILE3. These items are identified in the list below, but will not be presented in this document. Documents on the humidity correction factor for NO_x and nonmethane hydrocarbon emissions

have already been published, and other analyses are under way either by EPA or under a support contract. It should be noted that the air conditioning and trailer towing correction factors will not be updated for MOBILE3.

1. VMT vs. age distribution.
2. Registration vs. age distribution.
3. Diesel sales fractions.
4. Speed correction factors.
5. Temperature correction factors.
6. Evaporative emissions.
7. Idle emissions.

3.0 BASIC EXHAUST EMISSION RATES

Sections 3.1 through 3.3 discuss tampered vehicles identified in the 1975-80 emission factor sample and their emissions. However, estimates of the emission impacts of tampering for MOBILE3 were not necessarily developed from these vehicles. For more information on the manner in which the effects of tampering were included in MOBILE3, refer to the "Anti-Tampering and Anti-Misfueling Program to Reduce In-Use Emissions From Motor Vehicles" report (December 31, 1983, EPA-AA-TSS-83-10).

3.1 Identification of Tampered and Misfueled Vehicles

The 1975 and later light-duty vehicle data base was searched for vehicles with signs of air pump tampering, missing catalysts, widened fuel tank filler necks, lead values in gasoline above 0.05 g/gal, and EGR tampering. Vehicles with missing air pumps, belts, or disabled air pump hoses were considered to have tampered air pump systems. Vehicles with widened filler necks or lead fuel values exceeding 0.05 g/gal or both were considered to be misfueled vehicles. Vehicles with disconnected EGR vacuum hoses or missing EGR valves were considered to be EGR tampered vehicles. The number of tampered and misfueled vehicles found in the EF sample is shown in Table 2.

Table 2

Number of Tampered or Misfueled Light-Duty Vehicles
1975-80 Vehicles, All Regions

Tampering/Misfueling Type	Number Tampered
EGR	208
Lead above 0.05 gms/gal	66
Filler Neck	39
Air Pump	11
Catalyst Removed	9
Total Number of 1975-80 Vehicles Searched	4171

The two predominant types of tampering, EGR tampering and fuel lead values above 0.05 g/gal, are discussed in the following paragraphs.

3.2 EGR Tampered Vehicles

The number of vehicles with EGR tampering and their average NO_x emissions as compared to the vehicles without EGR tampering are shown in Table 3.

Table 3

Number of EGR Tampered Vehicles and Average NO_x Emissions, Low and High Altitude

Region	MYR Group	Tampered N	Tampered %	Tampered Mean NOx (gpm)	Untampered N	Untampered Mean NOx (gpm)
Low Altitude (Non-Calif.)	1975-76	42	2.3	3.91	1825	2.49
	1977-79	77	4.5	4.37	1632	1.98
	1980	11	1.9	3.62	584	1.71
High Altitude	1975-76	10	3.8	2.49	251	1.79
	1977-79	8	1.9	3.00	412	1.24
	1980	4	3.2	0.92	120	0.89

The data in Table 3 indicate that EGR tampering rates in the EF sample are within the 2-5% range, and that EGR tampered vehicles have significantly higher NO_x emissions than those without EGR tampering.

3.3 Vehicles With High Lead Fuel Values

Not all 1975-80 EF vehicles had tests for lead content of the fuel. In fact, very few of the 1975-79 vehicles had lead tests, while many more 1980 vehicles had lead tests.

The number and percentage of vehicles with high lead values (exceeding 0.05 grams/gal) is shown in Table 4. The low and high altitude regions seem to have about the same rate (5-10%).

Table 4

Number and Percentage* of Catalyst Vehicles With High Lead Values (greater than .05 g/gal)

MYR Group	Low Alt. N	Low Alt. %	High Alt. N	High Alt. %
1975-79	19	7.8	2	5.6
1980	36	7.7	8	10.5

* The percentage is calculated as the number of catalyst vehicles with high lead values divided by the total number of catalyst vehicles with lead tests.

The average emissions of vehicles with low and high lead fuel content is shown in Table 5. For 1975-79 vehicles, HC and CO emissions are higher in the high lead vehicles. For 1980 vehicles, the average HC and CO emissions of vehicles with high lead values are slightly lower than the low lead vehicles.

Table 5

Average Emissions of Cars with Low and High Fuel Lead Values: Low Altitude, Non-California

Pollutant	MYR Group	Low: Less than .05 g/gal	High: Greater than .05 g/gal
HC	1975-79	2.10	2.80
	1980	0.76	0.59
CO	1975-79	25.52	36.47
	1980	9.43	8.22
NO_x	1975-79	2.42	2.71
	1980	1.75	1.54

The 1980 cars have lower emissions in the high lead group because that group contains no high emitting HC/CO vehicles. For example, the maximum HC value of the high lead cars is 2.79 gm/mi. In contrast to this, the low lead group contains seven vehicles over 4.1 gm/mi, with one at 13.7 gm/mi. A similar comparison could be made for CO.

A better comparison of the emission effects of misfueling for 1980 EF vehicles would be to focus on the emissions of high lead versus low lead cars in the sample of vehicles that omits all low lead cars with emissions above the highest emission value of the high lead cars. This technique removes those low lead cars that have high emissions for factors other than misfueling. The comparison is shown in Table 6.

Table 6

Average Emissions of 1980 Cars with Low and High Lead Fuel Values without High-Emitting Low Lead Cars

Pollutant	--Emissions (gm/mi)-- Low Lead	High Lead
HC	0.56	0.59
CO	7.30	8.22

The data in Table 6 indicate that the emissions of high-lead cars are higher than low lead 1980 cars, but only slightly. One explanation for the small difference in emissions of high and low lead cars is that the owners with the high lead cars that have agreed to participate in emission factor programs may only infrequently misfuel with leaded fuel. This type of infrequent misfueling does not damage the catalyst as much as persistent misfueling with leaded fuel.

3.4 Low Altitude Emission Rates

3.4.1 HC and CO

The low altitude HC and CO 1975-79 and 1980 emission rates for vehicle samples with and without the tampered and misfueled vehicles are presented in Table 7. Model year groups are the same as those used in MOBILE2. The "all" code under Tamp/Mfuel status means that no vehicles are excluded. The "no tamp" status means that vehicles with evidence of air pump tampering, filler neck tampering, lead values above 0.05 gms/gal or with catalysts removed are excluded. Vehicles with EGR tampering were included for the HC and CO emission rates, since EGR tampering has been demonstrated to not influence HC and CO emission rates significantly.* The emission rates in Table 7 are somewhat lower than the MOBILE2 emission rates, which are presented in Table 8.

Table 7

Low Altitude Emission Rates of 1975-80 LDV's -- Current Analysis

MYR	Tamp/Mfuel		-----HC-----		----CO-----	
Group	Status	N	ZML	DR	ZML	DR
1975-79	All	3576	1.09	0.26	18.33	2.16
	No Tamp	3512	1.07	0.27	18.23	2.59
1980	All	595	0.36	0.10	6.10	0.74
	No Tamp	556	0.36	0.10	6.09	0.73

Removal of tampered and misfueled vehicles seems to have little impact on the emission rates. This was expected, since the frequency of tampering in the EF sample was found to be low (each item with the exception of EGR tampering is less than 3.5%).

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* This was a conclusion in "Light Duty Driveability Investigation", EPA/460-3-78-012, Dec., 1978. When fourteen 1978 cars underwent EGR disconnections, average HC decreased 1.4%, average CO increased 0.9%, and average NO_x increased 210%.

Table 8

MOBILE2 HC and CO Exhaust Emission Rates
for 1975-80 LDGV's at Low Altitude

	------HC------		-----CO------	
MYR Group	ZML	DR	ZML	DR
1975-79	1.29	0.29	20.16	2.86
1980	0.29	0.29	6.14	2.86

The most notable differences between MOBILE2 and MOBILE3 are in the HC and CO deterioration rates for 1980 vehicles: the new estimates are about one-third of the MOBILE2 estimates. The 1980 EF sample includes the 1980 GM vehicles which have sealed carburetors.* Recent regressions of 290 1980 GM vehicles have estimated the HC and CO DR's to be 0.06 gm/mi/10K and 0.42 gm/mi/10K, respectively. These are lower than the DR's developed for the 1980 EF sample which includes all manufacturers.

3.4.2 NO_x Emission Rates

The low altitude NO_x emission rates for 1975-80 vehicles are shown in Table 9. These were estimated after the same tampered and misfueled vehicles were removed as were removed for the HC/CO analysis, with the addition that EGR tampered vehicles were also removed. Removal of the EGR tampered vehicles had a small impact on the emission rates. Also shown are the MOBILE2 NO_x emission rates.

Table 9

Low Altitude
NO_x Emission Rates for 1975-80 LDGV's

		Current --Analysis--		--MOBILE2--	
MYR Group	N	ZML	DR	ZML	DR
1975-76	1815	2.44	0.03	2.43	0.04
1977-79	1582	1.70	0.09	1.69	0.10
1980	544	1.50	0.07	1.56	0.10

The emission rates from the current analysis in Table 9 are changed very little from the MOBILE2 emission rates.

* Although GM used sealed carburetors on most 1979 models, their proportion of the 1975-79 sample is much smaller than their proportion of the 1980 sample.

3.4.3 Summary of all Low Altitude Pre-1981 Rates

The proposal is to use the new estimates as presented in Tables 7 (without tampering) and 9 for 1975-79 and 1980 emission rates at low altitude for MOBILE3. The pre-1975 emission rates would be the same as in MOBILE2. This ignores the effect of tampering on pre-1975 emission rates. However, the current analysis has demonstrated a rather small impact on the emission rates from the low level of tampering in the EF sample. Also, pre-1975 vehicles had few emission controls to be tampered (catalysts, for example), so tampering was likely a smaller problem on these vehicles. Therefore, ignoring pre-1975 tampering very likely does not pose a problem of accuracy with respect to the pre-1975 emission rates.

The new rates for all pre-1981 years are presented in Table 10. The MOBILE2 50K emission levels are presented for comparison.

Table 10

MOBILE3 Exhaust Emission Rates for 1980
and Earlier Low Altitude 49-State
Light-Duty Gasoline Powered Vehicles

Pollutant	Model Years	ZML	DR	50K Mile Emission Level	MOBILE2 50K Emission Level
HC	Pre-1968	7.25	0.18	8.15	8.15
	1968-69	4.43	0.25	5.68	5.68
	1970-71	3.00	0.37	4.85	4.85
	1972-74	3.36	0.17	4.21	4.21
	1975-79	1.07	0.27	2.42	2.74
	1980	0.36	0.10	0.86	1.74
CO	Pre-1968	78.27	2.25	89.52	89.52
	1968-69	56.34	2.55	69.09	69.09
	1970-71	42.17	3.13	57.82	57.82
	1972-74	40.78	2.44	52.98	52.98
	1975-79	18.23	2.59	31.18	34.46
	1980	6.09	0.73	9.74	20.44
NO_x	Pre-1968	3.44	0.0	3.44	3.44
	1968-72	4.35	0.0	4.35	4.35
	1973-74	2.87	0.04	3.07	3.07
	1975-76	2.44	0.03	2.59	2.63
	1977-79	1.70	0.09	2.15	2.19
	1980	1.50	0.07	1.85	2.06

3.5 High Altitude Emission Rates

3.5.1 HC and CO Emission Rates

Analysis of covariance yielded the high altitude zero mile levels and deterioration rates in a manner similar to low altitude.

In the MOBILE2 analysis, a test of equal DR's for all three pollutants at low and high altitudes was rejected only once (1970-71 CO emissions) at the 5% level of significance. Therefore, the low and high altitude DR's were assumed to be the same. Since then, more data have been collected at low and high altitude. The new data is showing that the assumption of equal low and high altitude DR's is being rejected also for HC and CO emissions of 1978-79 vehicles. The significance levels are shown in Table 11. By the MOBILE2 criteria a significance level greater than .05 indicates that the hypothesis that the DR's are equivalent is accepted. Significance levels less than .05 indicate that the hypothesis is rejected.

Table 11

Significance Levels of the
Assumption of Equal DR's
Between Low and High Altitude:
1978-79 Vehicles

Pollutant	Region	N	DR	Significance
HC	Low	1027	0.23	.004
	High	290	0.44	
CO	Low	1027	1.92	.0002
	High	290	5.87	

An examination of the scatter plots of emissions versus mileage of 1978-79 vehicle at low and high altitudes reveals that there are many more high mileage vehicles (i.e., 60-100K) in the low altitude sample than in the high altitude sample. This leaves the impression that if more high mileage high altitude vehicles had been tested, the DR's would have been similar. However, an examination of the CO data in the high altitude mileage range (0-68K miles) for both altitudes revealed significantly more gross emitters in the high altitude sample than the low altitude sample. At high altitude, 4.5% of the vehicles were between 100 and 150 gm/mi CO. At low altitudes, the percentage of vehicles between 100 and 150 gm/mi CO was 0.7%.

The data on balance indicates that separate DR's should be used for 1978-79 vehicles at low and high altitude. However, since only one group is involved it was decided to preserve the consistency of the model (i.e., DR's of all model year groups at low and high altitude are equal) rather than to make an exception for one model year group. Also, using

different DR's for this group would not have much impact on the fleet emission rates. For example, on January 1, 1988, the 1978 and 1979 model year groups accumulate less than 8% of the fleet VMT. Therefore, the data at all altitudes and all regions will be used to establish DR's (where technologies and standards are similar between California and non-California vehicles), while the non-California altitude-specific data will be used to establish the low and high altitude zero mile levels.

For MOBILE2, the emission rates of 1977 vehicles at high altitudes were separated from the 1975-79 group creating three groups: 1975-76, 1977, and 1978-79. The reason for this was to adequately reflect the situation in 1977 in which manufacturers were required to meet the new vehicle emission standards at low and high altitudes. Manufacturers responded by selling very few models at high altitudes, and the requirement for meeting standards at high altitude was relaxed for the 1978 model year. Consequently, the MOBILE2 emission rates for high altitude are lower for the 1977 model year than for the surrounding model year groups.

The new HC and CO emission rates for LDGV's at high altitudes are shown in Table 12. Vehicles that were misfueled or had evidence of tampering (except for EGR tampering) were removed. Also shown are the MOBILE2 high altitude emission rates.

Table 12

High Altitude LDGV HC and CO Emission Rates

		HC				CO			
MYR		Current		MOBILE2		Current		MOBILE2	
Group	N	ZML	DR	ZML	DR	ZML	DR	ZML	DR
1975-76	255	2.02	0.27	2.41	0.29	43.07	2.59	50.46	2.86
1977	124	0.95	0.27	1.07	0.29	16.97	2.59	19.55	2.86
1978-79	290	2.10	0.27	2.10	0.29	39.78	2.59	39.39	2.86
1980	114	0.78	0.10	0.46	0.29	22.80	0.73	18.22	2.86

3.5.2 NO_x Emission Rates

The new NO_x emission rates for LDGV's at high altitude are shown in Table 13. The data set that was used in the preceding HC/CO analysis was used, except that EGR-tampered vehicles were also removed.

Table 13

High Altitude NO_x Emission Rates

MYR Group	N	---Current--- ZML	DR	---MOBILE2--- ZML	DR
1975-76	247	1.70	0.03	1.70	0.04
1977	121	1.42	0.09	1.42	0.10
1978-79	285	1.00	0.09	1.02	0.10
1980	110	0.82	0.07	1.02	0.10

3.5.3 Summary of Pre-1981 High Altitude Emission Rates for MOBILE3

Using the data from the current analysis, the high altitude emission rates for pre-1981 LDGV's for MOBILE3 are presented in Table 14. The MOBILE2 50K emission levels have also been presented for comparison.

Table 14

Exhaust Emission Rates for High Altitude
49-State Light-Duty Gasoline Powered Vehicles

Pollutant	Model Years	ZML	DR	50K Mile Emission Level	MOBILE2 50K Emission Level
HC	Pre-1968	9.35	0.18	10.25	10.25
	1968-69	5.60	0.25	6.85	6.85
	1970-71	4.58	0.37	6.43	6.43
	1972-74	4.58	0.17	5.43	5.43
	1975-76	2.02	0.27	3.37	3.86
	1977	0.95	0.27	2.30	2.52
	1978-79	2.10	0.27	3.45	3.55
	1980	0.78	0.10	1.28	1.91
CO	Pre-1968	117.70	2.25	128.95	128.95
	1968-69	85.54	2.55	98.29	98.29
	1970-71	79.64	3.13	95.29	95.29
	1972-74	75.63	2.44	87.83	87.83
	1975-76	43.07	2.59	56.02	64.76
	1977	16.97	2.59	29.92	33.85
	1978-79	39.78	2.59	52.73	53.69
	1980	22.80	0.73	26.45	32.52
NO_x	Pre-1968	1.96	0.0	1.96	1.96
	1968-72	2.91	0.0	2.91	2.91
	1973-74	1.91	0.04	2.11	2.11
	1975-76	1.70	0.03	1.85	1.90
	1977	1.42	0.09	1.87	1.92
	1978-79	1.00	0.09	1.45	1.52
	1980	0.82	0.07	1.17	1.52

4.0 CORRECTION FACTORS

The speed and temperature correction factors are being updated under a support contract from EPA data generated in FY83. The NO_x vs. humidity correction factor relationship was presented in another analysis*. The trailer towing and air conditioning correction factors used in MOBILE3 will be the same as those used in MOBILE2.

4.1 Normalized Bag Fractions

Normalized bag fractions are ratios of a bag's emissions to the FTP composite zero mile levels. They are used to predict the emissions if a user selects operating mode characteristics that are different from standard conditions (20.7% cold start, 52.1% stabilized, 27.3 hot start). New normalized bag fractions were computed from the new data for 1975-80 model years. The same values are used at both low and high altitudes. The new bag fractions are presented in Table 15.

Table 15

Normalized Bag Fractions for LDGV's

		--Seg. 1---		--Seg. 2---		--Seg. 3---		-Total Test-	
Pol	Model Year	B1	D1	B1	D2	B3	D3	Bo	Do
HC	1975-79	1.856	0.345	0.765	0.233	0.802	0.196	1.000	0.246
	1980	2.200	0.714	0.571	0.171	0.914	0.143	1.000	0.274
CO	1975-79	1.792	0.177	0.882	0.157	0.628	0.109	1.000	0.148
	1980	2.403	0.278	0.649	0.061	0.612	0.076	1.000	0.110
NOx	1975-76	1.297	0.012	0.781	0.004	1.194	0.016	1.000	0.009
	1977-79	1.371	0.040	0.766	0.046	1.166	0.063	1.000	0.049
	1980	1.313	0.047	0.810	0.034	1.125	0.054	1.000	0.042

* Memo from C. Shih to R. Stahman, September 1, 1983, "New Humidity Correction Factors for MOBILE3."